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Diving engines, submarine knowledge and the 'wealth fetch'd out of the sea'

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INTRODUCTION

In 1687, the Bostonian shipwright, William Phipps, secured the patronage of the Duke of Albermarle, along with a group of investors, to search and recover 'the vast wealth of gold and silver' from the Spanish wreck, the *Nuestra Señora de la Concepcion*. Phipps' expedition reportedly recovered over £200, 000 of silver from the ship, which had sunk off the coast of Hispaniola over forty years previously. According to one contemporary, the 'wealth that was fetch'd out of the Sea' was 'trumpeted all over the World, and set Mens Heads at work to get more,' drawing in an 'abundance of people […]of all qualities, gentle and simple, wise and otherwise.'[1] The expedition was documented in the anonymously-penned treatise *Angliae Tutamen or the safety of England* (1695), which identified diving, as well as mining, as a key site for the development of projects that had, in the words of the author, led to the 'destruction of trade and commerce' and the 'impoverishing of the realm.'[2] This account of the rise of 'pernicious projects' across the kingdom corresponded with a patent boom in the last decade of the seventeenth-century, where, according to Christine Macleod, the diving engine and its accompanying wreck-fishing expeditions became 'the epitome of 1690s projecting.'[3] The submarine represented a new 'trading zone' where a diverse set of people 'allur'd with the hopes of gaining vast riches' competed and collaborated 'to discover the hidden treasure of the ocean.'[4]

As recent work on the history of projecting has shown, the projector was most potent as a stereotype than a cohesive group, for in reality this was a complex figure that encompassed a variety of different people from engineers to experimental philosophers, merchants to government officials. Projectors were exposed to a high degree of distrust, and it was their supposed concern for private profit over public benefit that was said to compromise their integrity.[5] In fact, it has been argued that, within the circles of experimental philosophy, it was the financial disinterestedness of the gentleman that marked him apart from others as a particularly trustworthy speaker and therefore a reliable observer of nature.[6] However, the line

[1] *Angliae Tutamen or the safety of England* (London:1695), 3-4, 20-1. For more on the Phipps' expedition and the *concepcion* wreck, see Peter Earle, *The Wreck of the Almirante: Sir William Phips and the Search for the Hispaniola Treasure* (London: Macmillan, 1979).
[2] *Angliae Tutamen,* title page.
[3] Christine Macleod, 'The 1690s Patent Boom: Invention or stock-jobbing?', *The Economic History Review,* 39 (1986), 550; Christine Macleod, *Inventing the Industrial Revolution: The English Patent System 1660-1800* (Cambridge: Cambridge University Press, 1988).
[4] *Angliae Tutamen,* 21; *An exact and perfect relation of the arrival of the ship the James and Mary* (London: 1687), 1.
[5] See Koji Yamamoto, 'Reformation and the Distrust of the Projector', *Historical Journal*, 55 (2012), 375-97; Koji Yamamoto, *Taming Capitalism before its Triumph: Public Service, Distrust, and 'Projecting' in early Modern England*, (Oxford: Oxford University Press, 2018); Vera Keller and Ted McCormick, 'Towards a History of Projects', *Early Science and Medicine,* 21 (2016), 423-44.
[6] For instance, see Steven Shapin, *A Social History of Truth: Civility and Science in Seventeenth-Century England* (Chicago: Chicago University Press, 1994).

between the impartial pursuit of knowledge and the self-interested quest for money is problematised when we consider the experimental philosopher's intervention into the commercial sphere in cases such as mining and diving, where the motives for human intervention in exploring these environments are somewhat blurred. This article seeks to explore learned interest in the submarine within the context of quests for both knowledge and profit, considering the external, commercial influences on the experimental philosopher and the consequences this has for notions of disinterestedness. In doing so, it sets diving engines against attitudes towards the submarine and the challenges of experience in knowledge-making. It interprets diving engines and other underwater technologies as attempts to extend the limits of human experience – the essential basis for knowledge-making – and shows how the diving engine was imbued with the associated promises of gaining new submarine knowledge and the quest for retrieving precious materials from the bottom of the sea. Diving engines were instruments of both knowledge and use, for the submarine, like the subterranean, was an environment to be both studied and exploited.

'THE DARK RECESSES OF NATURE'

In his tract *Relations about the bottom of the sea*, Robert Boyle reported that 'tis great rarity in those cold parts of Europe to meet with any men at all that have had at once the Boldness, the occasion, the Opportunity and the Skill to penetrate into those conceal'd and dangerous recesses of nature.'[7] Boyle nicely conveyed the duality of attitudes towards the submarine; it was a concealed, dangerous, unknown space, often beyond the limits of human experience, but it simultaneously represented adventure and opportunity. 'Submarine', however, was seen as a problematic term, for, as Boyle acknowledged, it was used by the 'generality of learned men' to refer to 'subterraneous places', those under the body of the earth rather than 'the superficial parts of it.'[8] He therefore clarified his own usage of the term, using submarine to refer to that area 'not below the bottom of the sea, but only below the surface of it.' 'Submarine' was a relatively new term. Francis Bacon's reference to coral as a 'submarine plant' in *Sylva Sylvarum* appears to be the first use of the word in print, thus placing the concept of the 'submarine', and its origins, directly in the context of natural inquiry.[9]

Both the symbolic and physical connection between the submarine and the subterranean is clearly observed in the network of subterraneous passages that were said to link the seas and the central abyss. The abyss was another multi-layered term; it could refer generally to a bottomless and void space as well as the formless chaos out of which the earth and the heavens were created, but in physico-theological discourse, it tended to denote 'the sea, or subterraneous waters hid in the bowels of the earth.'[10] This internal sea figured prominently in physical explanations for the Universal Deluge, for it was thought to account for the vast volume of water required to flood the earth. Genesis related that the earth was flooded through the opening of the floodgates of heaven, providing forty days and forty nights of rain, as well

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[7] Robert Boyle, 'Relations about the bottom of the sea', *The Works of the Honourable Robert Boyle*, 6 vols (London: 1772) III, 349.
[8] Boyle, 'Of the temperature of submarine regions', *Works,* III, 345.
[9] Francis Bacon, *Sylva Sylvarum, or a natural history* (London: 1627), 202.
[10] Thomas Burnet, *The Theory of the Earth* (London, 1684), 14.

as the breaking of the wells of the great deep, the abyss. According to Thomas Burnet, whose *Sacred Theory of the Earth* dominated debate on the origins of the earth in late seventeenth-century England, it was the abyss that answered 'the great mystery of the deluge', for the quantity of rain suggested by the Mosaic account was insufficient to submerge the earth in water. The biblical concept of the abyss was transferred into the discipline of natural history, as naturalists, such as John Ray and John Woodward, discussed the means of communication between the central abyss and the surface of the earth. Using the Caspian Sea as an example, Ray argued for the 'confluence and communication of seas by underground channels and passages', for the Caspian, and many others, 'receives into itself many great rivers and yet have no visible outlets.' He concluded that it was by subterraneous passages that seas could 'discharge their waters into the Abyss of waters under the Earth, and by its intervention into the ocean again.'[11] Similarly, Woodward argued for a communication, or 'continual intercourse', between the abyss, 'the bowels of the earth', and the earthly atmosphere, discussing the dispatch 'of a great variety of principles out of the abyss': 'some humid, others dry, some cold, others hot, others of saline and mineral nature.' This, he argued, was evidenced in the phenomena observed in 'grottos and deep subterranean caverns, as well as Autumn fogs and vapours, which were sent up my subterranean heat.'[12]

Notions of the abyss physically linked the submarine and the subterranean and often placed learned ideas of the underwater within a religious framework. Where Boyle used the term 'submarine', Robert Hooke often employed the term 'abyss' to refer to the underwater, using it interchangeably to refer to the deep sea and the subterranean sea in the centre of the earth. Indeed, as Edmond Halley acknowledged in his account of the Universal Deluge, the breaking up of the great fountains of the deep mentioned in Genesis could refer to either the 'rising up out of the ground of the waters under the earth, spoken of in the second commandment, or by the overflowing of the sea, rising upon the land.'[13] Hooke explained that the abyss was more properly rendered the 'great deep' in the English translation of the bible and that the sea 'was call'd the abyss, and by the abyss was meant a Depth, not possible to be sounded or measured by the power of art.'[14] The deep sea and the biblical notion of the abyss (the subterranean sea) were closely entwined. There was a fine line between natural history and physico-theology in the late-seventeenth century, for both were part of a 'dual discussion' where nature and the

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[11] John Ray, *Three physico-theological discourses* (London: 1713), 76, 85.

[12] John Woodward, *Natural History of the World*, 122-23. Questions surrounding the structure of the earth and its historical transformations were part of wider set of debates that circulated across Europe. Athanasius Kircher had argued for the existence of a subterranean ocean in *Mundus Subterraneous* (1664), which he posited as the cause of tides, while the theories of Benôit de Maillet and Gottfried Leibniz on the organic origins of fossils were based on the notion that the earth had once been submerged under water. See Rhoda Rappaport, *When Geologists Were Historians, 1665-1750* (Ithaca: Cornell University Press, 1997); Paolo Rossi, *The Dark Abyss of Time: The History of the Earth and the History of Nations from Hooke to Vico* (Chicago: University of Chicago Press, 1987); Andre Wakefield, 'The Origins and History of the Earth', *The Oxford Handbook of Leibniz*, <https://doi.org/10.1093/oxfordhb/9780199744725.013.006> (accessed April 2018). In the late eighteenth and early nineteenth centuries, the idea of a universal sea was central to the arguments of James Werner and the Neptunists, who argued that rocks were formed through the build-up of sediment in the primordial sea.

[13] Edmond Halley, 'Some considerations about the cause of the Universal Deluge', *Philosophical Transactions*, 33 (1724), 119-20.

[14] Robert Hooke, *Philosophical Experiments and Observations of the late eminent Dr Robert Hooke* (London: 1726), 228.

bible could not be interpreted without reference to one another.[15] As such, biblical notions of the abyss were often subsumed into naturalistic discourses on the submarine as the works of Ray and Woodward indicate. The Mosaic account of nature held a high degree of authority amongst naturalists and natural philosophers, especially since - as we shall see in the following section - empirical information from the submarine environment was difficult to obtain. Hooke himself developed a range of submarine instruments or 'messengers' to seek to explore the mysteries of the deep, which he thought would 'afford many useful informations.'[16]

Conceptions of the submarine - linked to the dark spaces of the subterranean and the divine mystery of God – contextualise historical attempts to explore the under water. Questions relating to depth, salinity, and vegetation of the submarine all featured in Boyle's list of maritime inquiries, published in the *Philosophical Transactions*, and extended to consider 'the bottom of the sea and how it differs from the surface of the earth, in relation to soil; and evenness and roughness of the superficies; and the stones, minerals, and vegetables there.' Such inquiries bore resemblance to those regarding the subterranean: the situation and depths of mines, the condition of stones, and the minerals to be found there.[17] Just like the earth, the sea was a space to be mined for both information and commodities.

EXPERIENCE, KNOWLEDGE-MAKING AND THE SUBMARINE

Scripture, and indeed other textual sources, played an important role in natural inquiry and conceptions of nature, but, within the scientific community of late seventeenth-century England, it was personal, sensory experience that was publicly promoted as the essential means for establishing matters of fact. Boyle, Hooke, and others closely associated with the early Royal Society ascribed to what Peter Dear has described as a new type of empiricism 'rooted in the authority of the individual reporter as the actor in a well-defined, particular experience.'[18] There were, however, some obvious challenges to experiencing the submarine. In his account on the bottom of the sea, Boyle admitted that he did 'not pretend to have visited the bottom of the sea', but pointed out that neither had any other naturalists who had written on the subject. How then did one make submarine knowledge? Boyle contented himself with drawing on the experience of others, 'learning by enquiry' which he distinguished from the 'hearsay' relied on

[15] David Beck, 'Regional Natural History in England: Physico-theology and the exploration of nature', *Society and Politics*, 6, no. 2 (2012), p. 23. Also on physico-theology and the sciences, see Eric Jorink, *Reading the Book of Nature in the Dutch Golden Age, 1575-1715,* trans. Peter Mason (Leiden: Brill, 2010); William Poole, *The World Makers: Scientists of the Restoration and the Search for the Origins of the Earth* (Witney: Peter Lang, 2010).

[16] Hooke, *Philosophical Experiments and Observations*, 228-29.

[17] Robert Boyle, 'Other Inquiries Concerning the Sea', *Philosophical Transactions,* 1 (1665), 315-16; Robert Boyle, 'General Heads for a Natural History of a Countrey, Great or Small, Imparted Likewise by Mr. Boyle', *Philosophical Transactions,* 1 (1665), 186-89.

[18] Peter Dear, 'Totius in verba: Rhetoric and authority in the early Royal Society', *Isis,* 76, no. 2 (1985), 157. Also see Peter Dear, *Discipline and Experience: The Mathematical Way in the Scientific Revolution* (Chicago: University of Chicago Press, 1995) and Lorraine Daston and Elizabeth Lunbeck (ed.), *Histories of Scientific Observation* (Chicago: University of Chicago Press, 2011). The empirical ethos of the Royal Society is reflected in their motto: *nullius in verba*. On the overlap between empirical and book learning, see Anthony Grafton, *New Worlds, Ancient Texts: The Power of Tradition and the Shock of Discovery* (Cambridge: Harvard University Press, 1995), and Gianna Pomata and Nancy Siraisi, *Historia: Empiricism and Erudition in Early Modern Europe* (Cambridge: MIT Press, 2005).

by other naturalists. In plainer terms, he explained that 'I must either make use of other men's testimonies or leave some of the remarkablest phenomena […] unmentioned.'[19] Firstly, this involved conversing with divers who had travelled to the bottom of the sea 'some without, and some by the help of engines', including one particular man who 'gets his living by fetching up goods out of wrecked ships.' Secondly, Boyle would draw observations from those who had encountered the practices of pearl fishing in the East Indies, thus moving into the territory of third-hand testimony.[20] Both sets of sources generated different sets of issues regarding the integrity of relators and the credibility of their testimony.

The credibility of testimony was naturally intertwined with the credibility of the relators themselves. Steven Shapin has argued that, in seventeenth-century England, credibility was aligned with modes of gentlemanly honour and that the financial disinterestedness of the gentleman was taken as a guarantor of his trustworthiness as a reliable observer of nature. In fact, Shapin uses the case of divers to demonstrate the issues arising from non-gentle informants and how 'gentlemanly-philosophical culture' could discredit their experience and testimony by assigning greed, ignorance or bias to the diver's testimony, thus 'transforming direct experience into deceit or delusion.'[21] The discrediting of divers' reports, however, generally emerged when testimony could not be explained in accordance with existing theoretical frameworks or in individual cases where divers were deemed 'persons void of curiosity and skill to make much observations.'[22] Indeed, when testimony did not conform to Boyle's expectations, he would solicit the testimony of others or 'the testimony of things' (objects in experiments) to confirm it. It should not be assumed that non-gentle testimony was routinely rejected on the basis of its perceived 'vulgarity', for there were a number of instances when the experience of divers could be used to corroborate existing ideas about 'submarine phenomena.' On the issues of water pressure, for instance, Boyle used the testimony of divers, alongside his own and other's experiments on the compression of glass phials, to establish an empirical case against those who denied the effects of compression:

> Another thing observed at the bottom of the sea is the great pressure of water there against any other bodies. For whatever men may philosophize in their studies, and may conclude from the principles that are generally received about the non-gravitation of water in its proper place, yet experience seems very little to favour this general doctrine…Having inquired of two observing persons, whereof one had with a diving engine visited the bottom of the sea in a cold northern region; and the other had done the like in an engine much of the same sort on the coast of Africk; I found their relations to agree in this, that the deeper they descended into the sea, the more the air they carried down with them was compressed.[23]

[19] Robert Boyle, *New Experiments and Observations Touching Cold, or an Experimental History of Cold*, (London: 1664), C7r.
[20] Boyle, 'Of the temperature of submarine regions', *Works* III, 345; Boyle, 'New experiments about the differing pressure of heavy solids and fluids', *Works* III, 647; Boyle, 'Relations about the bottom of the sea', *Works* III, 352.
[21] Shapin, *A Social History of Truth*, 265.
[22] Boyle, 'New experiments about the differing pressure of heavy solids and fluids', *Works* III, 647.
[23] Shapin, *A Social History of Truth*, 263; Robert Boyle, 'Relations about the bottom of the sea', *Works* III, 351-52.

Boyle had heard from various divers about the physical effects of going under water, how they were 'incommoded' by the pressure: 'their chests and bellys considerably prest against their ears, to their great trouble' and even occasionally leading them to spit blood.[24] Boyle's use of instruments and objects to corroborate this testimony indicate the necessity of mechanical assistance in exploring the underwater.

In the case of divers, diving and submarine experience, issues of trust were not strictly limited to considerations of the credibility of particular kinds of people; they were linked to general reservations about the very limits of human experience. There were reports of divers falling 'into a swoon', the pressure of the water causing their eyes to become blood shot, their noses to bleed and their ears to experience an incredible pain, which was likened to a quill penetrating the ear drum. This was not an environment that readily accommodated human activity and Hooke wrote that people were less knowing of submarine phenomena 'because they are out of our element'. As such, Hooke's early work on the submarine was directed towards mitigating the physical challenges of human experience under water.[25] In the 1660s, this related to devices designed to aid the diver's air supply, which were linked to the wider set of pneumatics experiments he conducted with Boyle using the famous air-pump (investigating 'how great a pressure a terrestrial or aerial animal could live, and consequently a man'). Hooke designed 'leaden boxes' to be used underwater whereby 'fresh air from above' would be supplied by pipes to 'whatever depth [the diver] should be able to descend, without prejudicing his health or life.' The divers' underwater work would be facilitated through 'a pair of convex spectacles', developed by Hooke, 'to accommodate him for seeing under water' and 'to act freely in water as he could do in air.'[26] When these instruments were trialled and examined by a committee set up by the Royal Society, however, they were found ineffective. The report of the trials suggested that the problem was not with the instruments, but with human performance or compatibility, insinuating that this was what needed to be modified by recommending that the device be left with the diver so he could 'pursue the experiment by attempting frequent practices.'[27] In a second experiment, it was the operator of the Royal Society, Richard Shortgrave, who trialled the diving instruments. It was reported that the experiment – dropping the leaden box in a tub of water and having the operator 'respire the air in the said box by a pipe' – lasted four minutes 'but might have been continued longer, if the operator had stood in a more convenient posture.'[28] Again, it was reckoned that it was human capacity, out of its element, that rendered the technology ineffective.

[24] Royal Society (hereafter RS), London, Boyle Papers, Vol. 18, 60.

[25] RS, JBO/2/18, Meeting minutes, 9 March 1663/4; Edmund Halley, 'The art of living under water', *Philosophical Transactions* 29 (1714), 492-99; Robert Hooke, *Philosophical Experiments and Observations* (London: 1726), 313. Humans would need to imitate nature to operate outside their element; Hooke marvelled at the natural capacity of the nautilus shell-fish to descend freely through water, studying its movements and supply of air as a model for human submersion, while one early eighteenth-century diving engine required operators 'to act end ways [on their bellies] as do fishes and all water animals' (Hooke, *Philosophical Experiments and Observations*, 304-314; National Maritime Museum (hereafter NMM), London, ENG/5: Jacob Rowe, 'A Demonstration of the Diving Engine').

[26] Hooke, *Philosophical Experiments and Observations*, 313; RS, JBO/2/15, meeting minutes, 17 February 1663/4; RS, JBO/2/18, Meeting minutes, 9 March 1663/4; RS, JBO/2/27, meeting minutes, 11 May 1664.

[27] RS, JBO/2/28, meeting minutes, May 18 1664.

[28] RS, JBO/2/30, meeting minutes, June 1 1664.

Hooke did not dedicate himself to the subject for another thirty years. However, when he did, he switched his focus from the mechanics of human-operated diving engines and devices to unmanned technologies. If human experience was difficult to acquire, difficult to facilitate and sometimes difficult to trust, then the 'informations' of instruments could stand in their place. For this purpose, Hooke developed a range of underwater instruments he called *nuntii inanimate* (inanimate messengers) or *explorators abyssi* (explorers of the abyss) which were designed to respond to specific questions about the submarine environment. There was an *explorator* that measured the temperature of sea water at different depths (*explotator temperamenti*); one that sought to bring up samples of water from the bottom of the ocean (*explorator sustantiae*); and two that measured the depth and space of the sea (*explorator profunditatis* and *explorator distaniae*).[29] What is particularly interesting is how Hooke ascribed human agency to these instruments. He often referred to them as his 'messengers' who 'fetch me all the informations I desire' so that 'one might be ascertained of diverse things, yet never known to mankind.' The *explorators* conducted inquiries, collected information and returned with a 'a true account of what he was sent to inquire'; they acted, quite literally, as mechanical divers.[30] This did not necessarily mean that they were more trustworthy, however, for as Hooke pointed out, his devices could be 'liable to uncertainty' given the unknown conditions, such as the heat and cold, 'in those very deep, sub-marine regions.'[31]

Assembling information from either human or mechanical divers was beset with problems, though we do get a sense of some of the central motives behind submarine exploration. At first glance, this could be seen as an extension of curiosity, another natural environment to be mined for information that would make a distinct contribution to the grand, Baconian project for a complete history of nature. Hooke was therefore emphatic about the role of his *explorators* in collecting or confirming information from the bottom of the sea, information that 'no man now living, or ever did live upon the earth, hath experimentally known.' However, we get a sense that this was about more than collecting information: 'we want *nuntii* or messengers to send thither to bring us back informations and also the productions and commodities that this *terra incognita* or unknown world, does afford,' Hooke wrote.[32] Although this can only be subtly observed in his own writing, Hooke's instruments were devised to mine the sea for its productions, as well as the information it offered; he was, after all, highly interested in the animals and vegetables that one could find at the bottom of the ocean and how they differed from those on the surface of the earth. In fact, the very origins of his work on underwater instruments and diving engines should be viewed within a wider utilitarian framework, especially when we consider it in the context of the meetings of the Royal Society from which it arose in the 1660s. The Royal Society had their first meeting in November 1660, and within

[29] Hooke, *Philosophical Experiments and Observations*, 228-48. These were all questions that previously featured in the Royal Society's general and maritime inquires, which were published in the *Philosophical Transactions* for travellers, merchants and seamen to conduct. For instance, see 'Directions for seamen, bound for far voyages', *Philosophical Transactions,* 1 (1665), 140-43; 'An Appendix to the Directions for Seamen', *Philosophical Transaction,* 1 (1665), 147-49; 'Directions for observations and experiments to be made by masters of ships, pilots, and other fit persons in their sea-voyages', *Philosophical Transactions,* 2 (1667) 433-48; Robert Boyle, *General heads for the natural history of a country great or small* (London: 1692), 12-18.
[30] Hooke, *Philosophical Experiments and Observations,* 229, 233, 238.
[31] *Ibid.,* 230, 235.
[32] *Ibid.,* 240, 313.

six months, they had instructed that a diving engine should be prepared 'with the utmost expedition.'[33] As their first charter stated, the group were concerned with 'matters philosophical, mathematical, and mechanical' and so their work was engaged in both the 'science of natural things' as well as 'useful arts.' Amid hostility to the triviality of the new experimental philosophy, the Royal Society were eager to evidence the fruit of their labours: diving being one of the many 'useful arts' promoted by the fellows in its early years.[34]

In addition to this first diving engine, which was trialled at Deptford on the River Thames, the Royal Society assembled two diving committees within their first five years. One committee was appointed to assess Hooke's 'new way of diving', involving the pipes and leaden box discussed above. Shortly after being appointed on the committee, the Scottish natural philosopher Sir Robert Moray delivered a paper to the Royal Society from a person, a 'Mr Maule', 'who had done very notable feats under-water in a bell, at 24, 25, and 26 fathom depth as taking ballast out of a ship, sawing asunder the decks of ships, in order to the taking out of guns &c.' The diver, Moray reported, sought advice from the Royal Society on 'how to convey a good number of barrels under water at a great depth, for the raising of sunk ships', while another account he received related the ability of a diver at Dieppe who was able to stay under water for two hours or longer 'taking out of ships things of value.'[35] The utilitarian potential and practical ends of diving engines were also evident in a committee established earlier that year to examine a new diving instrument produced by the instrument-maker Ralph Greatorex. This was at the desire of the naval officer Sir John Lawson, who sought a committee to examine the instruments efficiency for underwater work 'or to direct a good method of staying under water for a considerable time, to lay the foundation of the mole at Tangier.' Lawson had, along with the Earl of Teviot and Hugh Cholmley, recently received a contract to construct a stone pier, or mole, in order to protect the harbour of the recently acquired English territory of Tangier.[36] As much as Hooke's engines and instruments were created to communicate information from an unknown, often inaccessible environment, they originated from a wider utilitarian impulse that recognised their potential in facilitating economic activity and protecting military interests. It is therefore of little surprise that Hooke returned to the subject of his underwater instruments in the early 1690s when the success of the Phips' expedition animated the public imagination and the ocean floor was exposed as a new, lucrative, commercial site.

BELLS, BULLION, AND UNDERWATER PROJECTORS

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[33] RS, JBO/1/32, meeting minutes, June 13 1661.

[34] 'Translation of the First Charter, granted to the President, Council, and Fellows of the Royal Society of London by King Charles the Second A.D. 1662': <https://royalsociety.org/about-us/governance/charters/> (accessed March 2017). For more on utility and the Royal Society, see Michael Hunter, *Science and Society in Restoration England* (Cambridge: Cambridge University Press, 1981), chapter four, and Kathleen H. Ochs, 'The Royal Society of London's History of Trades Programme: An Early Episode in Applied Science', *Notes and Records of the Royal Society*, 39, no. 2 (1985), 129-58.

[35] RS, JBO/2/18, Meeting minutes, 9 March 1663/4; RS, JBO/2/19, meeting minutes, 16 March 1664. The trial of Hooke's device took place two months after Maule's paper was read.

[36] RS, CMO/1/36, meeting minutes, 13 January 1664.

As *Angliae Tutamen* pronounced, the 'wealth that was fetch'd out of the Sea' during the recovery of the *Nuestra Señora de la Concepcion* 'set Mens Heads at work to get more.' In England, patents were sought and granted for diving engines for 'the sole fishing of wrecks on the coasts of America, Spain, Portugal, Ireland, Scotland, and England' and numerous 'societies [were] form'd of merchants and gentlemen to manage this affair.'[37] From 1672 to 1689, five patents were granted for diving engines, but in the first three years of the 1690s this more than doubled (notwithstanding the even higher number of petitions for patents that were filed.)[38] These engines were of 'various make':

> some like a Bell, others a Tub, some like a compleat Suit of Armour of Copper, and Leather between the Joynts, and Pipes to convey Wind, and a *Polyphemus* Eye in the Forehead to give Light, and pretended mighty Feats, staying under Water many Hours.

Interestingly, the recovery of goods from the *Concepcion* wreck was, it appears, taken up by 'naked Divers, both White and Black' without any assistance from diving engines. However, as the author of *Angliae Tutamen* explains, people were taken with the 'noise' surrounding diving engines, 'led by fancy and so hook'd', and there were even reports of public shows and trials of them on the River Thames.[39] In his diary, Narcissus Luttrell recorded an experiment with the Duke of Leinster's 'engine for working for wrecks' whereby a waterman was furnished with 'a tin case fastned about his neck with two leather pipes' that allowed him to communicate with men in the boat above and who could blow air down the pipes. Luttrell judged that this may prove a 'useful invention', reporting that the man walked across the Thames 'from Whitehall to Somersethouse, taking up sand, stones, &c. from the bottom.'[40]

It appears that the Duke of Leinster's engine was specifically devised 'for working for wrecks' and his intervention into the business of diving raises interesting questions about the sorts of people involved in the development of diving engines and their commercial application. Indeed, the high status represented by the Duke of Leinster is not uncommon among promoters of diving and salvage schemes. Of those petitioners who received patents for their new diving engines, a number were of high rank and wealth; Henry Asycognhe, John Stapleton, and Samuel Winball, for instance, were all referred to as 'gentlemen' in their patent specifications and the Phipps' expedition itself was largely financed by the Duke of Albermarle. There was, however, a broader social mix to underwater projectors, including the engine-maker Isaac Thompson and Captain Benjamin Graves who collaborated with others on developing 'diving habit and engines for enabling a man to work one hour under water by means of an air pump.' We also see the experimental philosopher and astronomer Edmond Halley in partnership with a number of merchants associated with the Royal African Company, as well as a diving project from Samuel Weale, a customs official in Cornwall, who perhaps most closely resembles the stereotypical projector, his name appearing in three different patents

[37] *Angliae Tutamen,* 20
[38] Macleod, 'The 1690s Patent Boom: Invention or stock-jobbing?', 563.
[39] *Angliae Tutamen,* 20
[40] Narcissus Luttrell, *A Brief Relation of state affairs from September 1678 to April 1714* (Oxford: Oxford University Press, 1857), 559, 561.

– for a diving engine, stamping engine, and a new variety of dye – in the early 1690s.[41] There was a spectrum to projecting, and Daniel Defoe, in his 'An Essay on Projects', emphasised the importance of distinguishing between the honest and dishonest. However, this was a distinction that even Defoe struggled to observe, for he recalled his negative experience investing in the diving engine of the 'patent-monger' John Williams 'whose cully,' Defoe wrote, 'was nobody but myself.'[42]

To Defoe, the success of the Phipps' expedition had been problematic. It was a 'mere project', a lottery with a 'hundred thousand to one odds.' 'Bless us,' he wrote, 'that folks should go three thousand miles to angle in the open sea for pieces of eight!' It was the unlikely and enormous success of the Phipp's voyages that had made the notion of wracking ventures credible; as Defoe argued, if the Phipps' expedition had failed it would have been ridiculed 'as Don Quixot's adventure upon a windmill' and people would have been ashamed to have owned a share in the venture.[43] It was reported that each 'adventurer' received between £8000 and £10000 for every £100 invested and therefore 'on the shadow of expectation' many others 'form'd companies, chose committees, appointed officers, shares and books, [and] rais'd stocks' to fund similar recovery initiatives.[44] The place of the diving engine within these schemes varied, for companies could be granted or transferred patents for diving engines, which we see in the case of both Williams and Halley, or they could alternatively receive patents for specific wreckages, gaining rights over 'all wrecks, jetsam, flotsam, lagan, gold, bullion etc' in a particular geographical area.[45] This has led Macleod to dismiss diving bells as 'no more than 'window dressing' to reassure investors', for they were often used 'to provide the basis for a patent whose real value (if any) lay in the exclusive share of the seabed it assigned.' In fact, more generally, Macleod argues that the rise of patents in the 1690s did not

[41] The patent numbers cited below refer to those given in Bennett Woodcroft, *Titles of Patents of Invention, Chronologically Arranged, from March 2, 1617 (14 James I) to October 1, 1852* (London: Queen's Printing Office, 1854). The full specification of the patents is accessed through the British Library digital patent document store. Henry Asycognhe, Working under water. Patent no. 256 (1687); John Stapleton, Engine to work under water. Patent no. 318 (1693); Samuel Winball, Engine to work under water. Patent no. 333 (1694); Isaac Thompson, Captain Benjamin Graves, Thomas Joll, John Cuthbert, Apparatus for working under water. Patent no. 298 (1692); Stephen Evance, Francis Tyssen, John Holland, Edmond Halley, Apparatus for working under water. Patent no. 279 (1691); Samuel Atkinson, Samuel Weale, Nicholas Nicholls, Apparatus for working under water. Patent no. 283 (1691).
[42] Daniel Defoe, *An essay upon projects* (London: 1697), 11, 14.
[43] *Ibid.* 16.
[44] Luttrell, *A Brief Relation of state affairs*, 407. Also see William Robert Scott, *The constitution and finance of English, Scottish, and Irish joint-stock companies until 1720* (Cambridge: Cambridge University Press, 1910), 484-89; Defoe, *An essay upon projects,* 12. This structure of wagering and projecting was not dissimilar to mining ventures in the German lands, where capital from investors, or *Gewerken*, was necessary to sustain operations. For more on this, see Andre Wakefield, *The Disordered Police State: German Cameralism as Science and Practice* (Chicago: University of Chicago Press, 2009), 28, 40; Andre Wakefield, 'Silver Thaler and Ur-Cameralists' in Mary Lindemann and Jared Poley (eds.), *Money in the German-Speaking Lands* (Berghahn Books, 2017), 58-73; Tina Asmussen, 'The Kux as a Site of Mediation: Economic Practices and Material Desires in the Early Modern German Mining Industry', in Christine Göttler, Susanna Burghartz, Lucas Burkart (eds.), *Sites of Mediation - Connected Histories of Places, Processes, and Objects in Europe and Beyond, 1450-1650* (Leiden: Brill, 2016), 159-82.
[45] John Williams, Apparatus for working under water. Patent no. 308 (1692). For instance, see the rights granted to Thomas Neale in *Calendar of Treasury Books, Volume 10, 1693-1696* (London: Her Majesty's Stationery Office, 1935), 50, and *Calendar of State Papers Domestic: William and Mary, 1690-1* (London: Her Majesty's Stationery Office ,1894), 523.

necessarily correspond with a rise in inventing.[46] The financial impulse behind diving patents was often clear; one awarded to Henry Asycoch in 1687 specified how it would be useful 'in recovering and taking up any goods and merchandise lost under water', while another received by Michael Rosse and James Johnson in 1692 argued that their invention would allow one 'to take up any bullion, plate &c. without diving.'[47]

However, we must be careful not to identify these as purely commercial undertakings, just as we would be unwise to consider learned interest in the submarine as nothing more than the natural extension of genuine curiosity. The commercial nature of diving engines raises two important and related points. Firstly, the role of the gentility and nobility in diving projects undermines the image of the disinterested gentleman that Shapin has recovered from the writings of contemporary moral philosophy. The gentleman's economic free action meant that he was regarded a truth-teller for 'there was nothing that worked on such people to induce them to represent matters otherwise' and this, Shapin argues, was a moral code transferred into the realm of natural philosophy to mark out credible testimony.[48] Yet the names of gentlemen listed in patent applications and subscribing to joint-stock companies, as well as the roles of noble persons like the Dukes of Albemarle and Leinster in funding diving expeditions, undercuts this impression. While the condition of disinterestedness may have been presented as a marker of the gentleman in moral literature, the real, commercial dealings of numerous gentlemen are testament to the permeable boundary between the gentleman and the merchant that has become the subject of work on the eighteenth-century culture of commerce.[49] Furthermore, the particular case of Edmond Halley and his diving engine, which we shall now explore, is testament not just to the financial opportunism of the late seventeenth-century gentlemen, but to the overlap of knowledge and commerce in the work of the experimental philosopher. Here, I wish to explore Halley at the intersection of learned and entrepreneurial cultures and how his diving engine resulted from both epistemic and economic motives.

Halley's diving engine was more than 'window dressing' for a scheme that claimed a specific portion of the sea floor; it was a new experimental technology that was based on what he termed 'the art of living underwater'. This largely concerned 'the means of furnishing air at the bottom of the sea' and the methods for 'carrying this *Pabulum Vitae* [food of life] down to the diver', for without this the diver would be forced to 'return very soon, or perish,' 'ordinary

[46] Macleod, *Inventing the Industrial Revolution*, 81; Macleod, 'The 1690s Patent Boom: Invention or stock-jobbing?', 550.

[47] Asycognhe. Patent no. 256 (1687); Michael Rosse and James Johnson, Apparatus for working under water. Patent no. 294 (1692).

[48] Shapin, *A Social History of Truth*, 237. Shapin argues that the equation of gentlemen with disinterestedness and disinterestedness with truth-telling 'was said to be the case and this was what the canon of practical ethical writing enjoined one to act upon as if were the case' (p. 84).

[49] Critiques of Shapin's thesis argue that it is based on a series of assumptions about the behavior and identity of the Restoration gentlemen. See Mordechai Feingold, 'When facts matter', *Isis*, 87, no. 1 (1996), 131-139. For a summary of the debate concerning the interface between gentlemen and merchants in early modern Britain, see Natasha Glaisyer, *The Culture of Commerce in England 1660-1720* (Woodbridge: Boydell, 2006), 16-19. Also see Richard Grassby, *The business community of seventeenth-century England* (Cambridge: Cambridge University Press, 2002); Neil McKendrick, 'Gentlemen and players revisited: The gentlemanly ideal, the business ideal, and the professional ideal in English literary culture' in Neil McKendrick and R.B Outhwaite (eds.), *Business Life and Public Policy*: *essays in honour of D.C Coleman* (Cambridge: Cambridge University Press,1986) 98-136; Peter Borsay, *The English urban renaissance: culture and society in the provincial town, 1660-1770* (Oxford: Clarendon Press, 1989).

persons generally beginning to stifle in about half a minute of time.'[50] Halley observed the practices of divers in the Bermudas who carried down sponges dipped in oil to aid their breathing and recounted the various other methods and engines that had been contrived to facilitate underwater respiration including the use of armoured suits and bellows as well as conical-shaped diving bells. The problem with these contrivances were numerous, according to Halley: bellows and armoured suits were only useful in small depths and were incredibly dangerous 'if there be the least defect in any of them', while the water entering into diving bells was said to contract the air within it 'into a small space, as that it soon heats and becomes unfit for respiration.' Halley sought to 'obviate these difficulties' by inventing a new means to convey fresh air to the bell.[51] This contrivance - 'so easy that it may be wondered it should not have been thought of sooner' - allowed 'old' air to be released through a valve and the air source replenished by air brought down from the surface in barrels weighted with lead and fixed with a hose that could then release the 'new' air into the bell. By these means, Halley argued that men could stay submerged for hours without ill consequence, reporting that he 'could, for a space as wide as the circuit of the bell, lay [at] the bottom of the sea so far dry.'[52]

This was about making the submarine environment amenable to human presence and James Delbourgo has interpreted Halley's project as an attempt to domesticate the submarine for human use, to covert wet into dry atmospheres, as part of a wider imperialist narrative of dominion. Indeed, Halley took delight in informing his readers that he could sit on a bench 'wholly drest with all my clothes on' even seeing well enough to read or write.[53] On another level, however, this was as much about extending human experience as it was territorial control. Whereas Hooke saw diving engines and instruments as a means to conduct underwater experiments, Halley saw the diving engine *as* the central experiment: an experiment to test the limits of human experience. The new system of air supply responded to the challenge of breathing underwater for long periods of time, but he also considered the other obstructions to the human senses under water that had obstructed the ability of natural divers to function under water. At the top of the diving bell, Halley installed a window of clear glass in order to let in light to facilitate the divers work and also developed an instrument 'for keeping fire under water', a kind of lantern 'without which they could not see or do anything.'[54] Experiments were also made on sound as Halley's own experience found that the water 'cut off all communication with the air above' and he therefore developed new ways of communicating with the ship above, sending up orders written with an iron pen on small plates of lead 'directing how to move us from place to place.'[55] To Halley, this was the 'art of living under water', techniques to facilitate human experience and activity in an otherwise unknowable and inhospitable

[50] Halley, 'The art of living under water', 492-99.
[51] *Ibid.*, 494-6.
[52] *Ibid.*, 496, 498. The addition of a 'vessel' or 'cap' to be worn on the head of the diver, which was attached to 'small flexible pipes', also allowed the diver to venture outside the Bell 'to be at liberty to do what he please there' (Halley, 'The art of living under water', 499; RS, JBO/9, 57-8, meeting minutes, October 7 1691).
[53] James Delbourgo, 'Divers Things: Collecting the World Underwater', *History of Science*, 49 (2011), 149-85; Halley, 'The art of living under water', 498.
[54] Halley, 'The art of living under water', 498-99; RS, JBO/9, 57-8, meeting minutes, October 7 1691; RS, Cl.P/21/39, Halley, 'Of conveying air out of the diving bell'.
[55] RS, Cl.P/21/31, Edmund Halley, 'Concerning sound under water and an instrument to enable there to be light under water'; Halley, 'The art of living under water', 499.

environment: 'to be there at liberty to act, or manage one's self to the best advantage as if one trodd upon the drie ground.'[56]

RAISING WRECKS, RAISING CAPITAL

The commercial undertones to Halley's project do not uncut its technological goals and epistemological aims, rather they sit alongside them. Halley's first paper on the ability of walking underwater was written in 1689, two years after the success of the Phipps' expedition was 'trumpet'd around the world.' It is therefore fitting that at the beginning of his first paper Halley spoke of his diving bell as a 'contrivance of great use in the saving of things lost in ships or otherwise.' In fact, Halley referenced the pearl divers in the West Indies in his paper 'who have lately been made use of to very good purpose in the recovering of the plate lost in the Spanish wreck', but pointed to the limits of natural diving and the use of the diving bell in countering them.[57] As Delbourgo highlights, the reference to the recovery of treasure was conspicuously absent from Halley's published version of the paper in the *Philosophical Transactions,* thus at least openly conforming to the image of the disinterested gentleman, though the other practical, and potentially commercial, applications of the engine were still explicit. This was an invention applicable to various uses: 'fishing for pearl, diving for coral, sponges and the like…also for the fitting and plaining of the foundations of moles, bridges etc. upon rocky bottoms; and for the cleaning and scrubbing of ships bottoms.'[58] However, the prime application for the invention was made abundantly clear in the patent awarded to Halley and his associates:

> Having observed what great losse incurrd by this our kingdome and other our dominions by casual shipwrecks and otherwise at sea for want of a way whereby persons might safely worke under water for the retrieving and regaining of all such gold, silver, buillion and coyned money, guns, jewels, and all manner of other goods, merchandizes, and things as have been lost at sea, and that they have at their very great charge and long travel therein, at length invented and found out a certaine new engine or instrument never hitherto knowne or practiced.[59]

Two years after Halley had begun his work on new types of diving bells, in 1691, the Royal Africa Company had requested his assistance in the recovery of a company frigate, the *Guynie*, which had sunk in the English channel holding a valuable cargo of gold and ivory.[60] This was the same year that Halley and his associates received their patent.[61]

[56] RS, Cl.P/21/28, Edmund Halley, 'To walk under water'.
[57] *Ibid.*
[58] Halley, 'The art of living under water', 499.
[59] Evance, Tyssen, Holland, Halley, Patent no. 279 (1691).
[60] The National Archives (hereafter TNA), Kew, T 70/83, ff. 41-43, 81. For more on Halley's involvement with the *Guynie* wreck, see Alan Cook, *Edmond Halley: Charting the Heavens and Seas* (Oxford: Clarendon Press, 1998), 234-43.
[61] Similar utilitarian functions were evident in Jacob Rowe's diving engine, which was clearly inspired by Halley's project. In his treatise, Rowe set out methods for finding wrecks; ways of blowing up rocks and ship-decks under water to facilitate salvaging; the use of lamps for working underwater; and how the engine could be used to inspect the bottom of the ship for leaks or 'any foulness, which may hinder her sailing' (NMM, ENG/5).

In developing his diving engine, Halley's goals were no doubt technological, but they were also knowingly channeled towards commercial ends. Two of Halley's initial associates were members of the Royal African Company (RAC), Sir Steven Evance and Francis Tyssen, and, following the joint award of the patent, the group petitioned for incorporation as 'Governor and Company for raising wrecks in England' (the company's shares prices being frequently quoted in John Houghton's *Collection for Improvement of Husbandry and Trade*). Later in 1691, an additional legal article of partnership was devised introducing a further two merchants as partners and shareholders. The article divided the diving patent into six hundred equal shares with sixty assigned to Evance and one-hundred and eight shares to the five other partners, including our gentleman philosopher, Halley.[62] This was a private scheme designed to secure profit for the patentees, and presumably the RAC, but like other projects it was fashioned as a form of public service, for the benefit of humanity, providing a safe means for working underwater. This idea of public benefit is captured in the very language of the patent, the crown willing to give 'all fitting encouragement to an invention which may be very useful and beneficial to the publick, and more particularly to trade and navigation.'[63] Of course, the state had a vested interest in many of these projects. Edmond Custis, in the early 1670s, had entered into an agreement with the Duke of York that entitled the duke to a share in the goods recovered using Custis's new way of 'taking up of goods out of wrecks and ships', while the patent awarded to Francis Smartfoot for his 'new invencon or sea crab for working in the sea', stipulated that the treasury be allocated a share of the 'merchandises, guns, treasure, and other things' that he might recover.[64] This was also the case for the Phipp's expedition where the royal mint received one-tenth of the silver recovered, and akin to the wider financial structures of the German mining sector that ear-marked a proportion of silver for the treasury.[65]

Diving engines were complex objects at the intersection of knowledge, commerce and politics. On an epistemological level, they extended the parameters of human experience, countering the challenges of human presence under water, which either constituted a technological achievement in itself, as in the case of Halley, or facilitated the collection of submarine information, as in the case of Hooke. These technological undertakings, however, cannot be divorced from their commercial potential, which we see particularly in the case of Halley, thus problematizing the association of disinterestedness with gentlemen and notions of credibility within the scientific community. Diving engines and underwater technologies should be understood within the context of quests for knowledge *and* profit, raising the question whether the two can really be disentangled. The fact that both Hooke and Halley turned to underwater technologies at a time when stories of treasure-hunting dominated the public discourse firmly suggests the power of commercial influence. Even Hooke spoke of his underwater messengers as delivering 'commodities and productions' of the sea floor, as well as information, while Boyle used the testimony of divers for the information it offered of the submarine environment, but the divers themselves travelled to the bottom of the sea for profit,

[62] TNA, C 111/192, packet 41.
[63] Evance, Tyssen, Holland, Halley, Patent no. 279 (1691).
[64] Edmund Custis, Raising sunken goods. Patent no. 163 (1671); Francis Smartfoot, Raising sunken ships. Patent no. 262 (1689).
[65] Christopher E. Challis, *A New History of the Royal Mint* (Cambridge University Press, 1992); Wakefield, *The Disordered Police State*, chapter 2.

not knowledge, collecting sponges, corals and pearls to sell. In one account of the Phipps' voyage, we even hear of the retrieval of a 'curiosity' from the wreck that was presented to the Duke of Albemarle: pieces of sunken silver that had 'white coral-trees growing thereon', representing the union of nature with money.[66] All this blurs the distinction between the epistemic and economic motives for venturing underwater.

[66] *An exact and perfect relation of the arrival of the ship the James and Mary*, 2.